Derivation of a statistical model for predicting poor control of Diabetes mellitus

ABSTRACT

This study was conducted to identify the factors associated with poor control of diabetes and to derive a statistical model for predicting poor control of type 2 diabetes mellitus. The overall framework of the study comprised of five phases: A systematic review and meta-analysis, self administered questionnaire survey, database development, prospective study, and calculator development.

In the first phase, a systematic review and meta-analysis was conducted, to summarize the factors associated with poor control of diabetes from various studies, conducted on type 2 diabetics. A comprehensive search was done by using various keywords to get all the observational studies, irrespective of region or languages. Those studies in which, it was impossible to discriminate data between the subjects with poorly controlled diabetes and not poorly controlled diabetes, and those conducted on type 1 diabetes or gestational diabetes were excluded from the review.

Meta-analysis was performed by pooling the results of selected studies. For meta-analysis Odds Ratio (O.R.) with 95% Confidence Interval (C.I.) and mean with Standard Deviation (S.D.) were retrieved from each study. Odds ratios were combined and Mantel-Haenszel Odds Ratio (M.H. O.R.) with its 95% C.I was calculated. For continuous measurements mean difference with 95% C.I. were calculated.
A two phase strategy was adopted for study selection. In the first phase, the titles and abstracts obtained were scrutinized for inclusion and in second phase full manuscripts of all the qualified studies from phase one were obtained.

Overall 7,501 studies were identified during the initial search, of which 43 studies were retrieved. Of these, 21 studies were included in the review and remaining was excluded because of either not satisfying the inclusion criteria or insufficient information. Among the 21 studies, 10 studies were qualified for meta-analysis. Methodological qualities of each study were assessed and data were extracted.

In this review diabetics with age > 60 years (M.H. O.R. = 1.61, 95% C.I. = 1.11 to 2.33), male gender (M.H. O.R. = 0.80, 95% C.I. = 0.72 to 0.88), and those with normal BMI (mean difference = 0.47, 95% C.I. = 0.38 to 0.55) had better control of the disease.

Smoking habit (M.H. O.R. = 0.89, 95% C.I. = 0.75 to 1.06), presence of depression (M.H. O.R. = 0.93, 95% C.I. = 0.69 to 1.26), increase in SBP or DBP, duration of diabetes (M.H. O.R. = 0.72, 95% C.I. = 0.49 to 1.07), medication compliance, fatty liver, foot problems, insulin use (M.H. O.R. = 1.02, 95% C.I. = 0.71 to 1.46), and metformin use (M.H. O.R. = 1.55, 95% C.I. = 0.57 to 4.24) were not associated with poor control of diabetes.

Presence of diseases such as: CHD (M.H. O.R. = 1.48, 95% C.I. = 1.17 to 1.87), neuropathy (M.H. O.R = 1.63, 95% C.I. = 1.19 to 2.22), retinopathy (M.H. O.R. = 1.61, 95% C.I. = 1.25 to 2.10), were associated with poor control of diabetes.
Non adherence to diet (M.H. O.R. = 6.22, 95 % CI. = 3.58 to 10.82), non adherence to exercise (M.H. O.R. = 1.43, 95 % CI. = 1.10 to 1.85), and intake of oral drugs (M.H. O.R. = 4.32, 95 % CI. = 2.42 to 7.71) were associated with poor control of diabetes. Use of Insulin (M.H. O.R. = 1.02, 95 % CI. = 0.71 to 1.46), and metformin (M.H. O.R. = 1.55, 95 % CI. = 0.57 to 4.24) were not associated with poor control of diabetes.

In the second phase, a self administered questionnaire survey was conducted among physicians, who have been regularly providing care to the type 2 diabetes, to understand their perception about the risk factors for poor control of diabetes mellitus. The perception component was categorized into four item scale: “strongly agree”, “agree”, “disagree”, and “strongly disagree”.

Fifty six physicians participated in this study. They strongly agreed that: abnormal body mass index (38; 68%), dietary factors (37; 67%), lack of physical activity (36; 64%), duration of diabetes (33; 59%), increase in the triglyceride levels or cholesterol levels (30, 55%), and presence of stress (28; 50%) were the important determinants of poor control of diabetes.

The physicians agreed that: C- peptide (39, 72%), age (34, 62%), diastolic blood pressure (34, 61%), presence of hypertension (31, 57%), presence of nephropathy (31, 57%), insulin treated diabetes (27, 55%), and SBP (28, 50%) as factors associated with poor control of diabetes. Few of them, disagreed that reluctance to prescribe insulin, and number of drugs prescribed as risk factors for poor control of diabetes.
In the third phase, a database was developed to store the epidemiological information about the diabetics. It includes, demographics, lifestyle, disease history, treatments, compliance, complications, and follow up details. The contents of the database were developed through various studies published in the field of glycemic control. It was used in phase four.

In the fourth phase, a prospective study was conducted. The objective of the prospective study was to derive a statistical model for predicting poor control of type 2 diabetes mellitus, at the initial stage of the disease.

For the six months follow up study, 3000 type 2 diabetics were recruited. Of these 2524 (84%) were completely followed up and 476 (16%) were lost to follow up. The followed up subjects (poorly controlled = 1084, 43%; not poorly controlled = 1440, 57%) were further divided into two groups. One group of subjects (n = 2100, 83%) was used for model derivation, and the remaining group was used for model validation (n = 424, 17%).

In this study, males (O.R = 2.21; 95% C.I = 1.85 to 2.63), habit of smoking (O.R = 1.23; 95% C.I = 1.03 to 1.48), habit of alcohol (O.R = 1.22; 95% C.I = 1.02 to 1.46), lack of exercise (O.R = 3.37; 95% C.I = 2.72 to 4.18), presence of hypertension (O.R = 0.72; 95% C.I = 0.56 to 0.92), and presence of neuropathy (O.R = 0.81; 95% C.I = 0.54 to 0.91) were associated with poor control of diabetes.
There was no association between: weight loss (O.R = 0.95; 95% C.I = 0.70 to 1.28), family history of diabetes (O.R = 1.09; 95% C.I = 0.89 to 1.34), coronary heart disease (O.R = 0.94; 95% C.I = 0.31 to 2.76), nephropathy (O.R = 1.09; 95% C.I = 0.69 to 1.73), diet compliance (O.R = 1.45; 95% C.I = 0.76 to 2.71), drug compliance (O.R = 1.10; 95% C.I = 0.55 to 2.19), and poor control of diabetes. Among those with the habit of smoking (O.R = 2.22; 95% C.I = 1.72 to 3.89), alcohol consumption (O.R = 1.35; 95% C.I = 1.14 to 1.89), and lack of exercise (O.R = 1.85; 95% C.I = 1.45 to 2.60) will get disease poorly controlled.

This study identified seven factors, which were associated with poor control of diabetes: age (years), gender (male/female), BMI (Kg/M$^2$), waist circumference (Cm), smoking (yes/no), alcohol (yes/no) and exercise (no/yes).

A probabilistic model was derived by using the identified factors and predicted the probability of poor control of diabetes. Sensitivity of the model was 63%, and specificity was 85%, Positive predictive value was 70%, and negative predictive value was 81%. The area under the ROC curve was 84%. Optimal sensitivity was 77%, and specificity was 87%.

In fifth phase, a calculator was developed to predict the probability of poor control of diabetes, based on the seven factors identified in phase four.

**Keywords:** Poor control of diabetes, Meta-analysis, Perception, and Statistical modeling.